

Using DataFed to Build Fire-related Web Applications

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Abstract DataFed (<http://datafed.net>) is a web infrastructure for accessing distributed air quality data and for processing and visualizing these data through web services. The modular and self describing web services available through DataFed are particularly well suited for conducting spatial and temporal data analysis of point datasets, such as satellite derived fire detection and surface fire observation data. Fire related data are available through numerous government web sites in the form of downloadable text files, images and Web Geographic Information Systems (GIS). While effective in accessing and visualizing fire data, these systems do not allow integration of data from other sources. DataFed is designed to combine data from multiple sources and to develop services for analyzing these data. This paper presents a case study for the type of “value-added” decision-support applications that can be developed using the DataFed infrastructure. The example applications provide tools for dynamically aggregating and comparing differences in fire location data through maps and time series.

I. INTRODUCTION

A recent workshop sponsored by NASA, EPA, and NOAA identified two primary issues in using fire data in air quality applications, 1) knowing what data were available and 2) understanding the relationships among similar fire data products (EPA/NASA/NOAA, 2004). The wealth of fire data, both collected in the field and derived from satellite measurements offer a tremendous resource, particularly when combined into an integrated fire product. Comparison of fire detection data derived from different collection techniques has revealed substantial differences in both spatial overlap and temporal agreement yet characterizing these differences is a prerequisite for their effective use (Boschetti, 2004; Soja et al, 2005). Taking advantage of a dataset’s unique characteristics (such as spatial resolution, sampling time, or fire detection algorithm) when combining multiple fire datasets could result in a more complete and accurate dataset for air quality applications, such as accurately estimating smoke emissions

Information technologies are making feasible the concept of a distributed web infrastructure that can assist in finding, analyzing, and integrating fire related data. Aided by new information science tools and computer science networks, researchers and decision makers, including those involved in fire management and air quality planning, are poised to exchange information more effectively, integrate data and

analyses more efficiently, and interact more actively (NSF, 2002; CyRDAS, 2004).

One set of technologies being actively pursued to achieve shared processing, analyzing, and visualizing of data are web services; self-contained software modules using XML-based standards for describing themselves and communicating with other web resources (Alameh, 2002; Thakkaret al., 2002). Web services are designed to be independent of any particular database or application platform, and are therefore ideally suited for building web applications.

Fire detection data analysis tools developed using web services are presented as examples of the type of “value-added” analysis possible through a web-based infrastructure.

II. DATAFED

DataFed (www.datafed.net) is a web infrastructure that provides a foundation for accessing distributed air quality data and for processing and visualizing these data through web services (Husar et al., 2005). DataFed provides mediator software for creating “views” of data, including maps, time series, and tables, that are distributed among multiple web servers. The views are created using web services, thereby allowing the data access, analysis, and visualization tools to be combined and reused in “custom-built” applications using standard web programming languages.

The initial step in building a DataFed web application is to *access data* sets through ‘data wrappers’ that translate the data from its stored format and make it readable in the DataFed development environment. The process of ‘wrapping’ data includes describing the data’s spatial, temporal and parameter properties as well as specific access instructions, such as ftp locations or SQL queries, for dynamically retrieving the data from its source. The query results can then be used to display, compare or otherwise process the data. Each data wrapper is specific to a data type (e.g. a lat/lon point data set in a relational database or a grid/raster data set).

Data processing and analysis are conducted by other, independently developed web services. The analysis services used in this work include spatial and temporal aggregation of point data (fire locations). The services use the output from data access services as the source of their input data. The aggregated datasets created by the analysis services are fed to

rendering services for displaying the results.

The settings of each web service in the access-analysis-rendering chain can be changed by the user, creating a dynamic web application. Each service is a standalone component making use of web standards, such as HTML, Web Service Description Language (WSDL) and Simple Object Access Protocol (SOAP), therefore offering the potential to link services together in user-defined, custom applications. Web applications using DataFed services can be built using most web programming languages where code or scripts are applied to dynamically control the services (e.g., change date, parameter, or dataset). The web applications described in this paper were built using either a combination of JavaScript and HTML or .NET and C#.

III. FIRE-RELATED DATA

Fire related applications are well suited for use by distributed web services. A variety of government, academic, commercial, and non-profit web sites disseminate an impressive collection of fire related data. The data available on these http or ftp sites include fire location, fire characteristics, vegetation, fire weather, modeled smoke patterns, and air pollution concentrations. The prevalence of fire related data and applications on the web is due to a variety of factors including attention given to recent severe wildland fire seasons, the wide range of organizations involved in managing fire and air quality, the multiple uses of the data, a variety of sensors collecting fire data, and the relative simplicity in communicating and understanding the data (e.g., fire location points or satellite images clearly showing the spatial extent smoke plumes).

DataFed was used to “wrap” numerous fire datasets through data access services, making them available for use by analysis and rendering services. A subset of the fire-related datasets catalogued in DataFed is described below.

The *Bureau of Land Management* has compiled a collection of fire records from Bureau of Land Management, Bureau of Indian Affairs, U.S. Fish and Wildlife Service, National Park Service, and U.S. Forest Service. The dataset includes fire location, acres burned and likely cause.

Forest Service Situation Reports provide daily summaries of fire activity including fire location and total acres burned. (<http://famweb.nwcg.gov/>)

NOAA-NESDIS Hazard Mapping System provides North American fire location and smoke plume data derived from MODIS, GOES, and AVHRR (<http://www.ssd.noaa.gov/PS/FIRE/>). A satellite imagery analyst inspects the fire detection data, deletes false alarms from the datasets and supplements them with fire locations

that are believed to have been missed by the satellite fire detection algorithms. (Ruminski et al., 2003).

The *Forest Service Remote Sensing Applications Center* provides maps and tables of active fires derived from MODIS. (<http://activefiremaps.fs.fed.us/>)

EPA's National Emissions Inventory contains county level emissions estimates for prescribed and wildland fires. (<http://www.epa.gov/ttn/chief/net/neidata.html>)

The *Forest Service's Wildland Fire Assessment System* provides fire weather data and information including national fire danger indices, drought indices, and meteorological measurements. (<http://www.fs.fed.us/land/wfas/>)

The *European Space Agency ATSR* satellite-based sensor detects fire pixels using only nighttime observations. Data are provided with global spatial coverage. (<http://dup.esrin.esa.it/ionia/wfa/index.asp>)

The *Canadian Wildland Fire Information System* includes a compilation of field observation forest fire data collected by Province, Territory, and Parks Canada fire agencies (Stocks et al, 2001). The data set includes only fires greater than 200 hectares in final size. (http://cwfis.cfs.nrcan.gc.ca/en/historical/ha_lfdb_maps_e.php)

The catalog of fire related datasets is accessible through the following URL: http://webapps.datafed.net/dvoy_services/datafed_catalog.aspx?domain=Fire.

IV. WEB APPLICATIONS

Fire location data are typically presented as maps for a specific day or time period. Web applications were developed to extend the exploration of fire location data to temporal analysis and spatial/temporal aggregation. The DataFed infrastructure was used to create a web service that interactively defines a set of grid nodes at which neighboring fire locations are counted. Spatially aggregated fire counts lend themselves to spatial pattern analysis and temporal trend analysis because the fire counts at each fixed location node create a record over time.

Figure 1 illustrates an example using fire pixel data from the NOAA-NESDIS Hazard Mapping System. During the summer of 2004, a number of large fires burned in central Alaska. The map in Figure 1 shows the aggregated fire pixel count on August 18, 2004 at nodes centered on 50km² radius grid cells. The size of each red square in the map is proportional to the number of fires counted at a node. The companion time series shows the temporal pattern of the fires for a particular node in the map. The time plot indicates an

outbreak of fires in late July followed by a lull until substantial fire activity is detected again in mid-August. Clicking on another location in the map or a different date in the time plot will update the display for the respective location or date thereby allowing simple exploration of the dataset.

Aggregating fire location data to a common spatial and temporal frame of reference offers a way to compare multiple datasets. MODIS and GOES fire pixel data are compared spatially and temporally through a web application interface as shown in Figure 2. On July 14, 2004 both MODIS and GOES fire pixel datasets from the NOAA-NESDIS HMS detect fires in Kansas. In general, GOES contains a larger number of fire pixels due, in part, to its higher sampling frequency (15 minutes versus approximately once per day for MODIS). This is particularly evident in the grid node highlighted by the cross hairs in the Figure 2 map. The corresponding June-October 2004 time series for the highlighted location superimposes the temporal trend of the MODIS (red) and GOES (blue) fire pixel count. Both sensors show a peak in fire pixel count on July 14, 2004 followed by a sharp decline on July 15 and 16. However, on July 18, 19, and 20, GOES again shows high fire activity whereas MODIS continues to decline. The differences exposed through the spatial and temporal analysis can assist in understanding the characteristics of each fire detection sensor and associated algorithm.

Datasets containing more detailed parameters allow further analysis of fire locations. For example, the BLM fire history dataset includes acres burned and the date a fire was discovered. Figure 3 presents a web application that spatially aggregates acres burned on a 50km² grid and temporally aggregates acres burned to a monthly resolution. The application includes a map with circles proportional to the sum of the acres burned at a location for a particular year and month. The time series plot shows the monthly total number of acres burned for a particular location. The example in Figure 3 has selected a location in southeastern Idaho where about 2000 thousand acres burned in July 1999. The map reveals that acres burned in the Idaho location are substantially less than in northern Nevada during the same month while the time series highlights that the July 1999 fires were much smaller than the 7500 acres burned in July 1992 in the same part of Idaho.

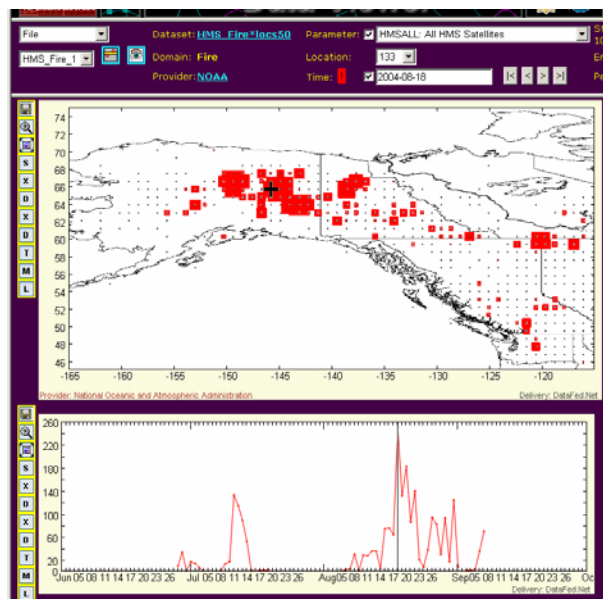


Figure 1. Spatial-temporal analysis of fire counts.

http://webapps.datafed.net/dvov_services/datafed.aspx?page=Fire_Pixel_Count_AK

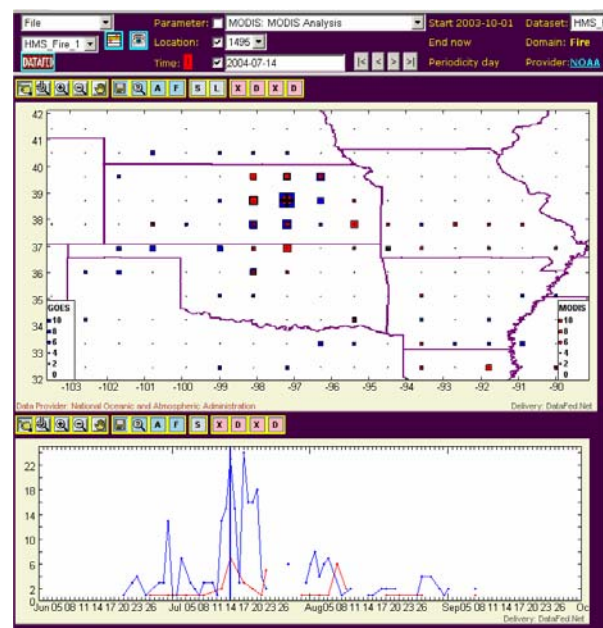


Figure 2. Spatial-temporal analysis of fire pixel data from MODIS (blue) and GOES (red).

http://webapps.datafed.net/dvov_services/datafed.aspx?page=Fire_Pixel_Count

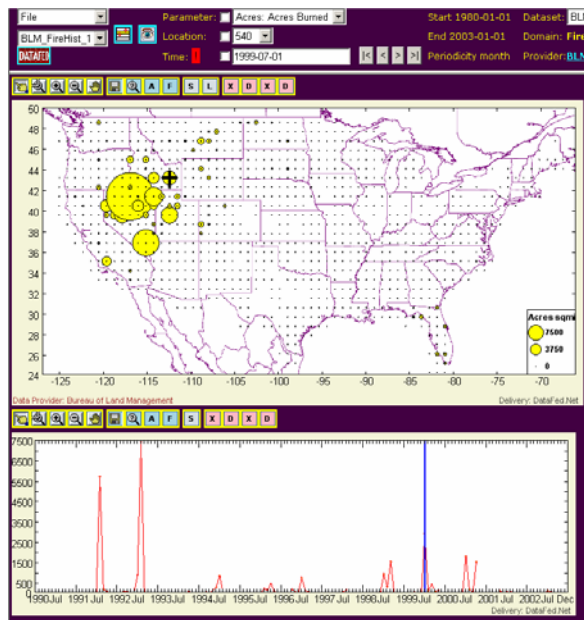


Figure 3. Spatial-temporal analysis of fire pixel data between MODIS (blue) and GOES (red).

http://webapps.datafed.net/dvov_services/datafed.aspx?page=BLM_AcresBurned

A web service was developed to conduct exploratory spatial-temporal analysis of fire location data among satellites and field observations. The service finds the nearest fire detection point in dataset B for each fire detection point in dataset A. The distance and number of days between a fire detection point in dataset A and its nearest neighbor dataset B are calculated and displayed on a map.

Figure 4 presents a comparison between GOES and MODIS fire pixels from the NOAA-NESDIS Hazard Mapping System where colored squares indicate the spatial and temporal correspondence between the two satellites derived fire pixel datasets. A red *shaded* square indicates the distance separating the MODIS and GOES pixels was small while a blue *shaded* square indicates the nearest neighbor between the datasets were far apart. A red *outlined* square indicates the nearest neighbor was detected on the same day while a blue *outlined* square indicates a longer time separation. Gray shaded and/or outlined squares indicate that a nearest neighbor was not found between the two datasets given the search parameters (in this example case, 100 km and 2 days). On July 17, 2004, both GOES and MODIS detected fires in the Central Plains. The distance (both in space and time) is small between GOES and MODIS pixels and are therefore colored red in the maps. The top map displays GOES fire locations colored by their distance to the nearest MODIS

pixel. The bottom map displays MODIS fire locations colored by their distance to the nearest GOES pixel. While there is good agreement in Kansas, the fires detected by MODIS in northern Texas were not detected by GOES (and are therefore colored gray).

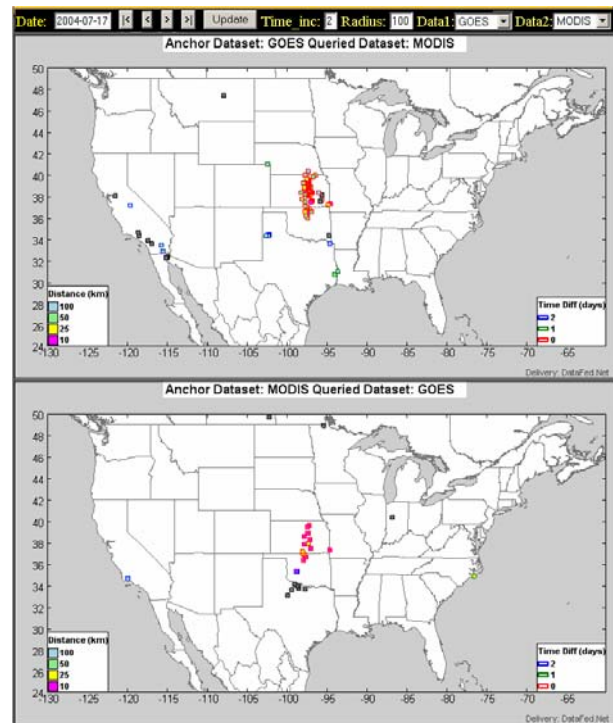


Figure 4. Spatial-temporal "distance" analysis of GOES and MODIS. Red indicates close correspondence between the two datasets

<http://www.datafed.net/WebApps/MiscApps/ModisGoes/FireLocationComparison.htm>

Further investigation is being conducted into integrating satellite derived with field observations of fires. Figure 5 presents an early comparison of MODIS derived fire pixels and fire incidents from the Forest Service Situation Report. As one might expect, on a day-to-day basis, the correspondence between the two datasets is mixed. On August 6, 2004 (top map in Figure 5) the two datasets show good correspondence in the Western US with the fires observed in the FS Situation Report and those derived from MODIS being near each other (in space and time). On the other hand, on August 24, MODIS does not detect fires in the vicinity of those observed by the Forest Service, perhaps due to cloud cover preventing detections by MODIS (bottom map in Figure 5)

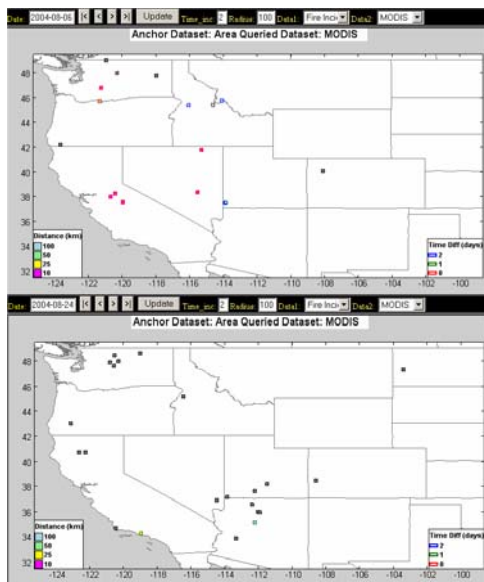


Figure 5. Spatial-temporal analysis of correspondence between MODIS and fires reported in the Forest Service Situation Report.

Effective analysis can also be conducted by a simpler aggregation of the data. Figure 6 presents a web application that displays all fire locations within a user-specified time range. In the case presented, the dates span the three week period, August 7 – August 27, 2004. The fire pixels derived from AVHRR are shown in the top map in Figure 6 while MODIS fires are displayed in the bottom map. MODIS and AVHRR show very similar spatial patterns in fire location distribution.

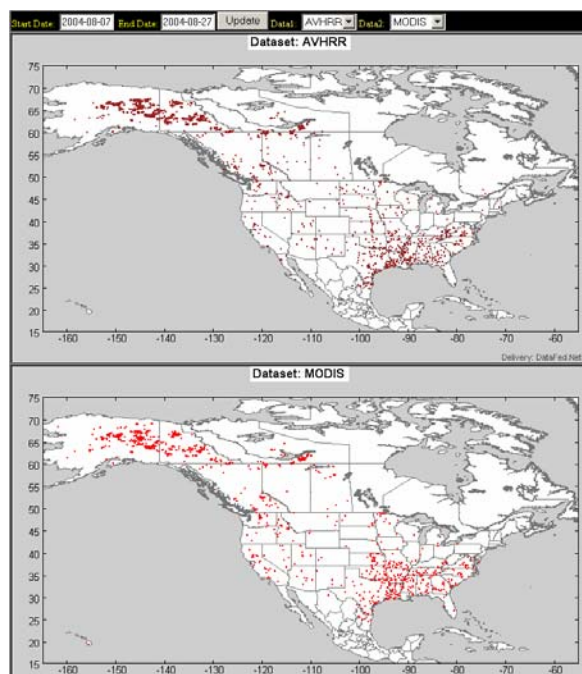


Figure 6. Time range comparison of fire pixels derived from AVHRR and MODIS.

<http://www.datafed.net/WebApps/MiscApps/Fire/FireLocation.htm>

DataFed built web applications provide a set of tools for conducting custom and dynamic spatial and temporal analysis of fire data. These types of comparative analyses provide the foundation for more involved analysis of sensor characteristics and algorithms that lead to differences between fire location datasets. The tools presented are designed to be flexible and adaptive so that they can import other datasets, be extended with more advanced analysis algorithms, or be used in a “chain” of processing services for other applications.

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